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ZOEAL LARVAE OF *MACROPHTHALMUS SETOSUS* H. MILNE-EDWARDS, 1852 AND *M. PUNCTULATUS* MIERS, 1884 (DECAPODA, OCYPODIDAE).

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ABSTRACT

All five zoeal larvae of *Macrophthalmus setosus* H. MilneEdwards, 1852 and the first zoeal larva of *M. punctulatus* Miers, 1884 cultured in the laboratory are described and illustrated. Comparisons are made with previously published descriptions of macrophthalmine larvae and on the basis of larval characteristics, the taxonomic status of *M. hirtipes* (Jacquinot, 1853) is questioned.

INTRODUCTION

Barnes (1967) recorded twelve *Macrophthalmus* species from Australia. The first zoeal larvae of three of these species i.e., *M. japonicus* (by Aikawa 1929) and *M. latreillei, M. pacificus*, (by Hashmi 1969) have been described from Japan and Pakistan respectively. Larvae of the nine other species are unknown, and no *Macrophthalmus* larvae have previously been described from Australian material. The present paper describes zoeal stages of *M. setosus* and *M. punctulatus* from eastern Australia.

Snelling (1959), in her study of the Brisbane River crab fauna, recorded three *Macrophthalmus* species i.e., *M. setosus, M. punctulatus* and *M. pacificus*. Subsequently Snelling's *M. pacificus* has been reidentified as juvenile *M. setosus* (Barnes 1967).

M. setosus and *M. punctulatus* are endemic to Australia (Barnes 1967), having a rather restricted distribution on the east coast, from south of the Tropic of Capricorn to central New South Wales. Both species are relatively common in the Brisbane River estuary. *M. setosus* is numerically dominant where it occurs, and is found under stones or on damp soft mud between L.W.N. and L.W.S. from the river mouth upstream for c. 22km where salinities are c. 10–30‰. *M. punctulatus* burrows into firm mud between H.W.N. and L.W.N. from the mouth of the river upstream for c. 11km where salinities are c. 18–35‰. It seldom occurs in large numbers.

The present paper is one of a series designed to describe the brachyuran larvae of an Australian estuarine assemblage.

MATERIALS AND METHODS

Ovigerous females were collected from the banks of the Brisbane River (27°23' S, 153°9'E) during summer. Captured crabs were held individually in plastic containers (160mm square X 220mm deep) filled to a depth of 50mm with pasteurized seawater having a salinity of 20‰ and at 25°C in an artificial light/dark regime of 12/12 hours. Each container was provided with a 90mm square raft of plastic gauze which the crabs could use as a shelter and emergence platform. Water was changed twice daily until surface mud and faecal material had been lost, and then once daily.

Newly hatched zoeae were transferred to similar plastic containers in batches of c. 2000. Rearing water (salinity 20‰) was renewed each morning when larvae were fed. Initially, freshly hatched *Artemia* nauplii were provided as food, but no zoeae moulted on this diet, the *Artemia* nauplii apparently being too active for the small crab larvae to handle. A complete zoeal series of *Macrophthalmus setosus* was subsequently obtained by providing *Brachionus* sp. as food.

Samples of each larval stage were preserved in 4% neutral formalin. Dissections were made under a Wild M5 microscope and drawings were made using a Wild M20 microscope with drawing tube.

Figures of zoeal stage II and IV appendages have not been included since these appendages do not differ markedly from those of the preceding stages. If required these figures can be obtained from the authors.

Setal nomenclature is based in that used by Bookhout and Costlow (1974). Measurements of larvae and tabular presentation of appendage segmentation and setation follow that used previously by the present authors, e.g., Greenwood and Fielder (1980).

RESULTS

Macrophthalmus (Mopsocarcinus) punctulatus Miers, 1884

ZOEA I (Fig. 1A-I)

First stage zoeae have, as yet, not been reared to later stages. Size and proportional measurements are given in Table 1.

Carapace smooth and globose. Dorsal and lateral spines absent. Rostrum very short and evenly tapered. Eyes immobile.

Abdomen with five free somites, sixth fused to telson; second and third abdominal somites each with a pair of dorso-lateral projections. Postero-lateral margins of all abdominal somites without spines. Paired setules postero-dorsally on somites 2-5. Telson width similar to that of last abdominal somite, telson length (medial) c. 1.2 times width; posterior margin transverse with 3 + 3 subequal biplumose setae. Telson rami short, c. 0.5 times telson length, 2 times length of posterior setae, each ramus with two longitudinal rows of setules, but no dorsal or lateral spines.

Structure and setation of appendages as given in Fig. 1C-I and Table 2.

Macrophthalmus (Mareotis) setosus H. Milne Edwards, 1852

Five zoeal stages were reared before cultures failed. However, the well developed thoracic appendages and pleopods of the fifth zoeal stage indicate that this is the last stage before megalopal transition. Each zoeal stage was completed in c. 8 days. Size and proportional measurements of zoeae are given in Table 1. Dorsal spine and rostral lengths are 0.6 to 0.7 times the carapace length in all zoeal stages. The dorsal spine is almost equal in length to the rostrum in all zoeal stages for which multiple measurements are available.

ZOEA I (Figs 2A, B; 3A-G)

Carapace smooth and globose with dorsal and rostral but no lateral spines. Dorsal spine uniformly tapered with a slight posterior curvature. Rostrum smooth, evenly tapered and straight. Eyes immobile.

TABLE 1. DIMENSIONS OF VARIOUS FEATURES OF THE ZOEAE OF *MACROPHTHALMUS SETOSUS* AND *M. PUNCTULATUS*. ALL MEASUREMENTS ARE IN MM AND UNLESS OTHERWISE STATED, MEAN VALUES, FOR 10 INDIVIDUALS OF EACH STAGE, ARE GIVEN WITH STANDARD DEVIATION IN BRACKETS.

	Macrophthalmus setosus					*M. punctulatus*
Feature	Zoea I	Zoea II	Zoea III	Zoea IV	Zoea V*	Zoea I
Spine to spine tip Range	0.68 (0.02) 0.64–0.72	0.81 (0.04) 0.76–0.86	1.10 (0.15) 0.96–1.30	1.38 (0.02) 1.36–1.40	1.58	—
Carapace (A) Range	0.32 (0.02) 0.30–0.34	0.41 (0.01) 0.40–0.42	0.51 (0.06) 0.42–0.58	0.69 (0.02) 0.66–0.70	0.80	0.31 (0.02) 0.28–0.34
Dorsal Spine (B) Range	0.23 (0.01) 0.20–0.24	0.24 (0.02) 0.22–0.26	0.34 (0.05) 0.28–0.40	0.46 (0.02) 0.44–0.48	0.54	—
Rostrum (C) Range	0.22 (0.02) 0.20–0.24	0.27 (0.02) 0.26–0.30	0.35 (0.05) 0.32–0.42	0.43 (0.01) 0.42–0.44	0.44	0.05 (0.01) 0.04–0.06
Antenna Range	c. 0.10	c. 0.15	0.18 (0.02) 0.16–0.20	0.28 (0.01) 0.28	0.32	0.10 (0.01) 0.08–0.12
Ratio B/A	0.72	0.59	0.67	0.70	0.68	—
Ratio C/A	0.69	0.66	0.69	0.62	0.55	0.17
Ratio B/C	1.05	0.89	0.97	1.07	1.23	—

* one measurement only

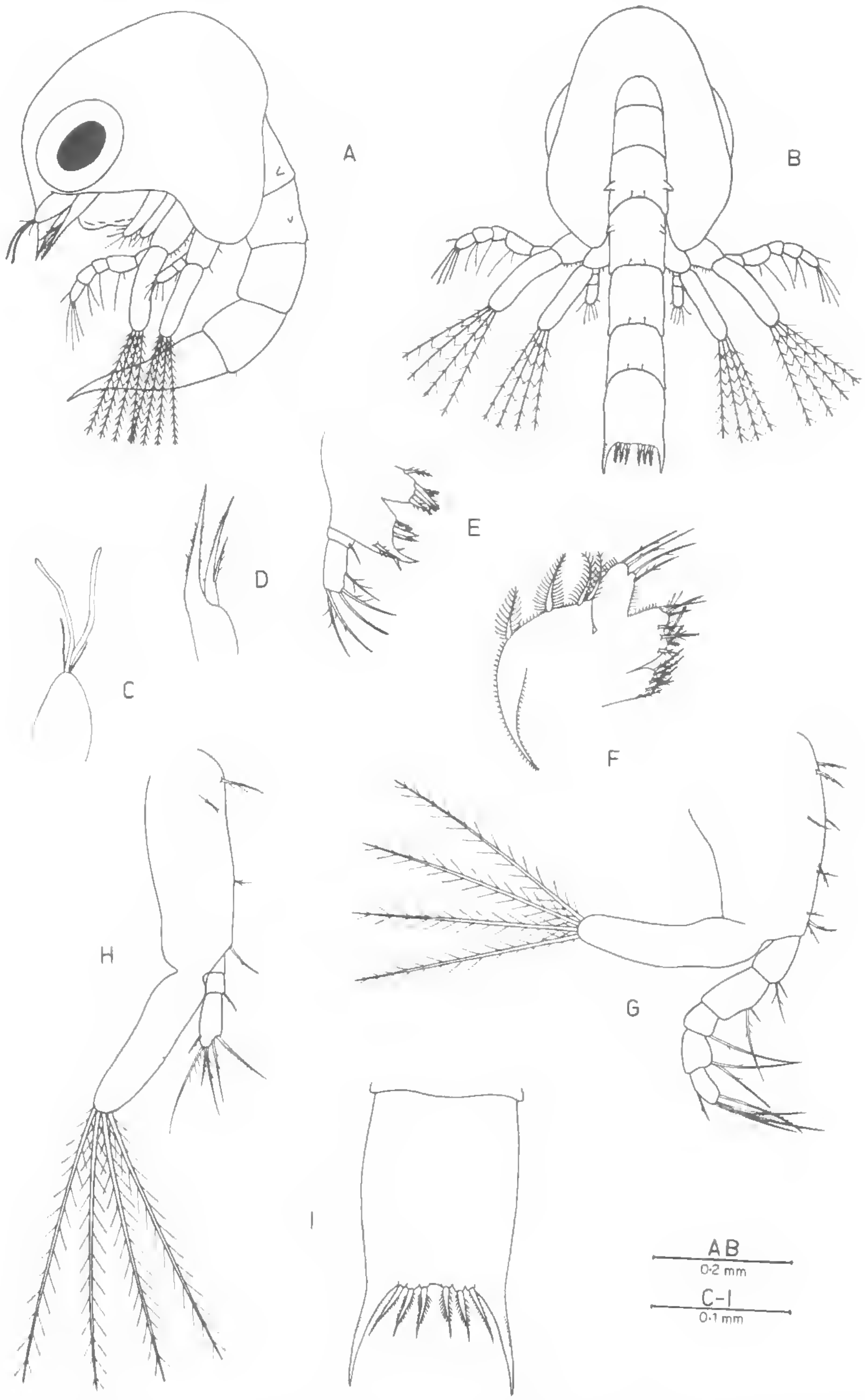

FIG. 1: *Macrophthalmus punctulatus*. **A**. first zoea lateral view; **B**. first zoea posterior view; **C**. first antenna; **D**. second antenna; **E**. first maxilla; **F**. second maxilla; **G**. first maxilliped; **H**. second maxilliped; **I**. telson.

TABLE 2. SEGMENTATION AND SETATION OF APPENDAGES OF ZOEAL STAGES OF *MACROPHTHALMUS SETOSUS* AND *M. PUNCTULATUS* (A = AESTHETE; S = SIMPLE; SP = SPARSELY PLUMOSE; P = PLUMOSE; HP = HIGHLY PLUMOSE; PD = PLUMODENTICULATE).

		Macrophthalmus setosus					*M. punctulatus*
Appendage		Zoea I	Zoea II	Zoea III	Zoea IV	Zoea V	Zoea I
ANT. I	Terminal	3A, 1S	6A	4A	5A	5A	3A, 1S
	Subterminal	0	0	0	1A	4A	0
ANT. II	Peduncle	10–15S	17–23S	18–25S	18–25S	12–17S	many S
	Exopod	1S	1S	1S	1S	1S	1PD, many S
	Endopod	—	—	—	present	present	—
MAX. I	Coxa	0	1HP	1HP	1HP, 1PD	1HP, 1PD	0
	Coxal end.	5PD	5PD	5PD	6–7PD	11PD	5PD
	Basal end.	3SP, 1PD	4SP, 3PD	4SP, 3PD	6–7PD	1–2S, 9PD	2SP, 2PD
	Endopod seg. prox.	1S	1S	1S	1S	1S	1S
	seg. 2	5PD	5PD	5PD	5PD	5PD	5PD
MAX. II	Coxal end. prox.	4PD	4PD	4PD	6PD	5HP, 2PD	4PD
	dist.	3PD	3PD	3PD	4PD	4HP, 1PD	3PD
	Basal end. prox.	5PD	5PD	5PD	6PD	7PD	5PD
	dist.	4PD	4PD	4PD	7PD	9–10PD	4PD
	Endopod	4PD	4PD	4PD	4PD	4PD	4PD
	Scaphognathite	5HP	8HP	14HP	c. 29HP	c. 30HP	5HP
MAX'PED 1	Basis	9PD	9PD	9PD	10–11PD	15PD	9PD
	Endopod seg. prox.	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S
	seg. 2	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S	1PD, 1S
	seg. 3	1PD	1PD	1PD	2PD	2PD	1PD
	seg. 4	2PD	2PD	2PD	2PD	2PD	2PD
	seg. 5	4PD, 1S	5PD	5PD	6PD	6PD	5PD
	Exopod	4HP	6HP	8HP	10HP	10HP	4HP
MAX'PED. II	Basis	2PD, 2S	2PD, 2S	2PD, 2S	4PD	4PD	4PD
	Endopod seg. prox.	0	0	0	0	0	0
	seg. 2	1S	1PD	1PD	1PD	1PD	1PD
	seg. 3	3PD, 3S	3PD, 3S	3PD, 3S	4PD, 2S	8PD	6PD
	Exopod	4HP	6HP	8HP	10HP	10HP	4HP

Abdomen with five free somites, sixth fused to telson; second and third abdominal somites with a pair of dorso-lateral projections. Abdominal somites 2–5 with very small postero-lateral spines. Paired setules postero-dorsally on somites 2–5. Telson width similar to that of last abdominal somite, telson length (medial) c. equal to width; posterior margin with 3 + 3 biplumose setae. Telson rami c. equal to telson length, twice length of posterior setae, each ramus with two longitudinal rows of setules but no dorsal or lateral spines.

Structure and setation of appendages as given in Fig. 3A–G and Table 2.

ZOEA II (Fig. 2C)

Postero-lateral spines on somites 2–5 now pronounced. Eyes mobile, no evidence of thoracic limb buds. Sixth abdominal somite still fused to telson. Telson now with 4 + 4 biplumose setae between rami.

Setation of appendages as given in Table 2.

ZOEA III (Figs 2D, 4A–F)

Sixth abdominal somite still fused to telson.

Structure and setation of appendages as given in Fig. 4A–F and Table 2.

ZOEA IV (Fig. 2E)

Pereiopod buds not yet apparent. Sixth abdominal somite now separate from telson. Pleopod buds now present on abdominal somites 2–5, tiny uropod buds present on sixth abdominal somite.

Setation of appendages as given in Table 2.

ZOEA V (Figs 2F, 5A–F)

Third maxillipeds and pereiopods well developed but not yet setose. Pleopods and uropods well developed.

Structure and setation of appendages as given in Fig. 5A–F and Table 2.

DISCUSSION

The larvae of *M. setosus* and *M. punctulatus* have been difficult to rear. Gravid females carry large quantities of mud on their surfaces which fouls aquarium water during the first few days of captivity. They also produce large quantities of 'muddy' faeces during this period which also fouls aquarium water. Full term eggs often did not hatch or were aborted during these first days, and mortality of hatched larvae was very high. A much greater problem was posed by the small size of the first zoeae. Freshly hatched *Artemia* nauplii cannot be used as food as they are too large and too active. Hashmi (1969) did not mention zoeal stages later than the first, for the five species of *Macrophthalmus* he hatched. Apparently *Artemia* nauplii provided by Hashmi as a sole food source were also not suitable in those cases.

In the present investigation, all zoeal stages (but no megalopae) of *M. setosus* have been reared using the much smaller rotifer, *Brachionus* sp. as a food source. It has not yet been possible to rear *M. punctulatus* beyond the first zoeal stage although repeated attempts have been made using *Brachionus* as food.

Based on the rather gross features of size and carapace spination, first stage zoeae of the genus *Macrophthalmus* are quite diverse. Like those of *M. setosus* (= 0.32 mm) and *M. punctulatus* (= 0.31 mm) described here, the first zoeae of most other *Macrophthalmus* species so far described are small and have carapace lengths of less than 0.4mm, i.e., *M. depressus* = 0.38 mm (Aikawa 1929; Hashmi 1969; Rice 1975); *M. dilatatus* = 0.38 mm (Aikawa 1929); *M. crinitus* = 0.29 mm, *M. latreillei* = 0.30 mm, *M. sulcatus* = 0.34 mm, *M. pacificus* = 0.38 mm (Hashmi 1969). On the other hand the first zoeal stage carapace length of *M. hirtipes* (Wear 1968) is relatively large at 0.45 mm. The most consistent complement of carapace spines so far described is dorsal + rostral. However, two species, i.e., *M. crinitus* and *M. hirtipes* have lateral carapace spines as well and *M. punctulatus* (present study) has a rostral spine only.

Rice (1975) used the setation of maxillule, maxilla and second maxilliped endopods to separate ocypodid zoeae into distinct groups which corresponded to the accepted sub-families based on adult morphology. Rice's (l.c.) larval *Macrophthalmus* setation with corresponding setation of *M. setosus* and *M. punctulatus* is shown in Table 3. It can be seen that zoeal larvae of both species conform closely to those listed by Rice.

Based on the presence of large lateral carapace spines and the absence of dorso-lateral knobs on abdominal somite 3, Fielder and Greenwood (1985) suggested that the larvae of *M. hirtipes* were not in the mainstream of *Macrophthalmus* larvae, but were closely allied to those of *Heloecius cordiformis* (now placed in a new sub-family, Heloecinae), and that the taxonomic status of *M. hirtipes* should be investigated. This suggestion is further supported when the telson and carapace length of zoeal larvae of *M. hirtipes* (described by Wear, 1968) are compared with those of *M. setosus* and *M. punctulatus*, and other known *Macrophthalmus* larvae. The distance between the distal tips of the furcal rami

TABLE 3. Selected First Zoeal Mouthparts Setation and Dorso-lateral Abdominal Projections of the Sub family Macrophthalminae (Rice 1980), *Macrophthlamus punctulus* and *M. setosus* (This Study).

	MAX. I	MAX. II		MAX'PED I	MAX'PED II	ABDOMEN	
	Endop.	Endop.	Scaphog.	Endop. basal seg.	Endop.	Dorso-lateral knobs Som. 2	Som. 3
Macrophthalminae	1, 4/6	2 + 2	4 + 1	2	0/1, 1, 5/6	1	1
M. punctulatus	1, 5	2 + 2	4 + 1	2	0, 1, 6	1	1
M. setosus	1, 5	2 + 2	4 + 1	2	0, 1, 6	1	1

of *M. hirtipes* zoeae is c. 3.0 times the width of the telson base and the telson length from base to furcal notch is c. 0.28 times the total telson length. Comparable figures for the other *Macrophthalmus* zoeae are not more than 1.4 and not less than 0.43 respectively. *M. hirtipes* zoeae are also substantially larger than other known *Macrophthalmus* zoeae.

One other species from the sub-family Macrophthalminae has been collected from the Brisbane River (Snelling, 1959), i.e., *Australoplax tridentata*. It is intended that zoeal larvae of this species will be described in a future paper. Thus it is premature, at this time, to discuss differentiating features of species within the sub-family on a local basis.

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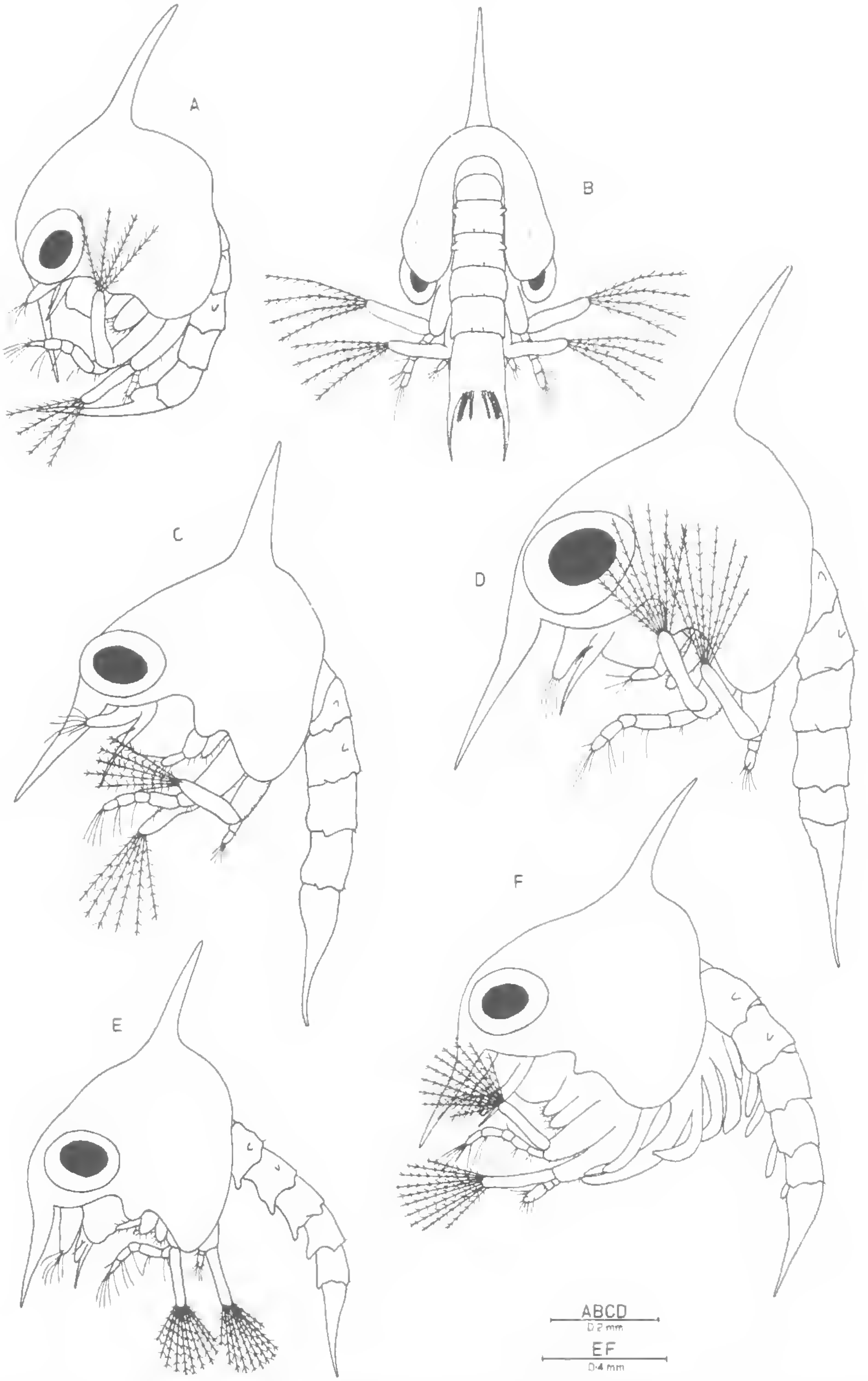

FIG. 2: *Macrophthalmus setosus*. **A**. first zoea lateral view; **B**. first zoea posterior view; **C**. second zoea; **D**. third zoea; **E**. fourth zoea; **F**. fifth zoea.

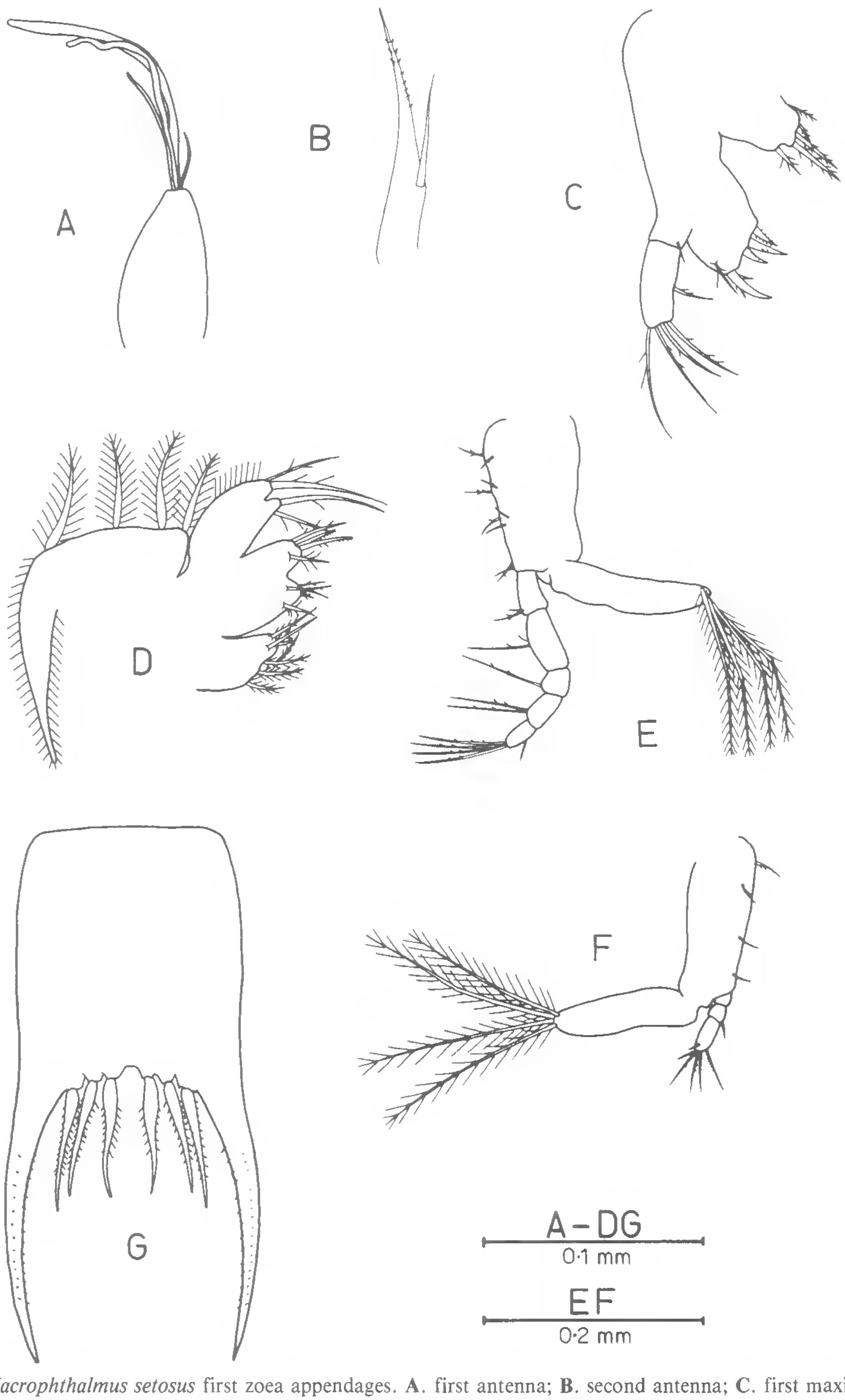

FIG. 3: *Macrophthalmus setosus* first zoea appendages. **A**. first antenna; **B**. second antenna; **C**. first maxilla; **D**. second maxilla; **E**. first maxilliped; **F**. second maxilliped; **G**. telson.

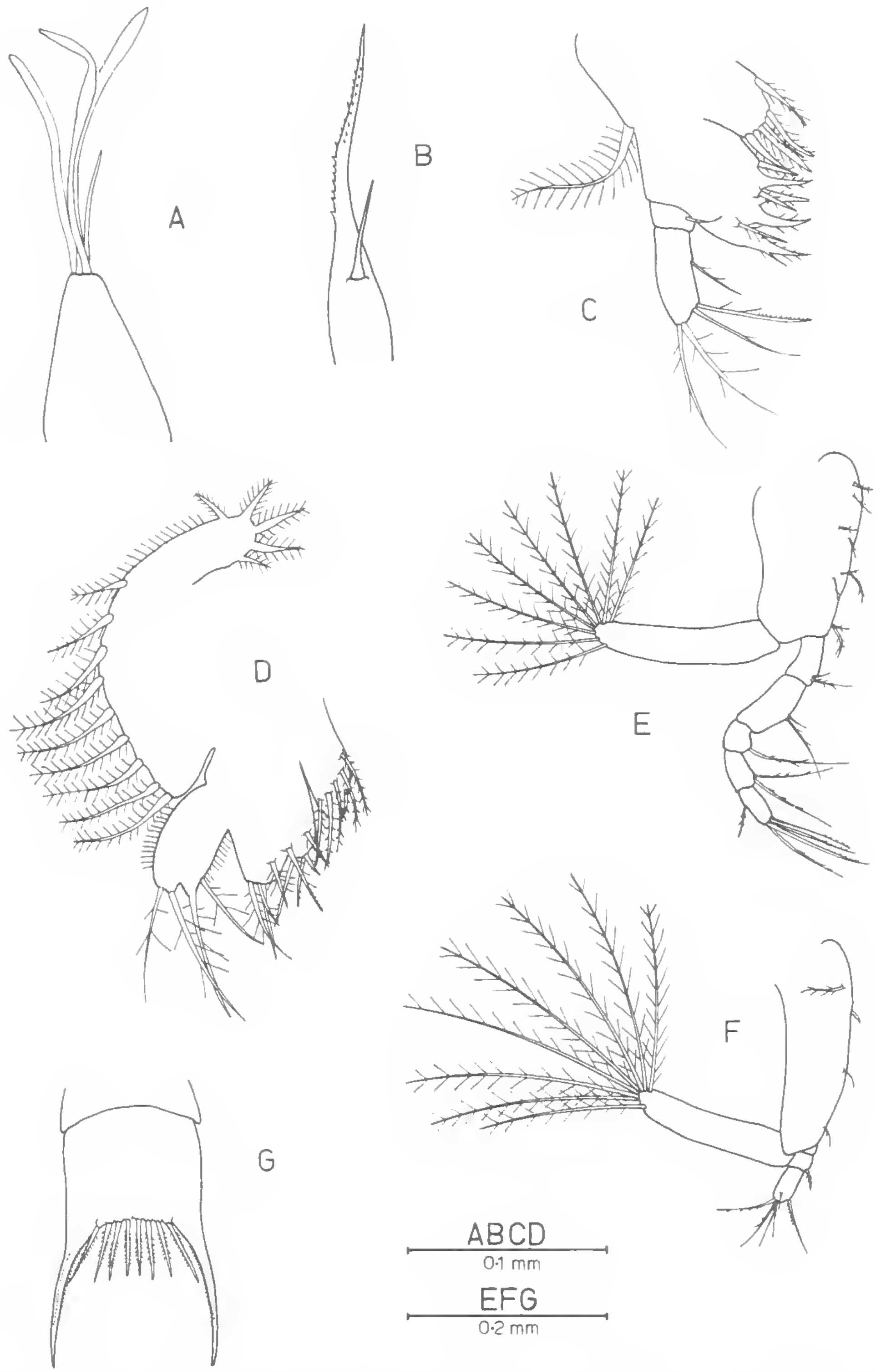

FIG. 4: *Macrophthalmus setosus* third zoea appendages. **A.** first antenna; **B.** second antenna; **C.** first maxilla; **D.** second maxilla; **E.** first maxilliped; **F.** second maxilliped; **G.** telson.

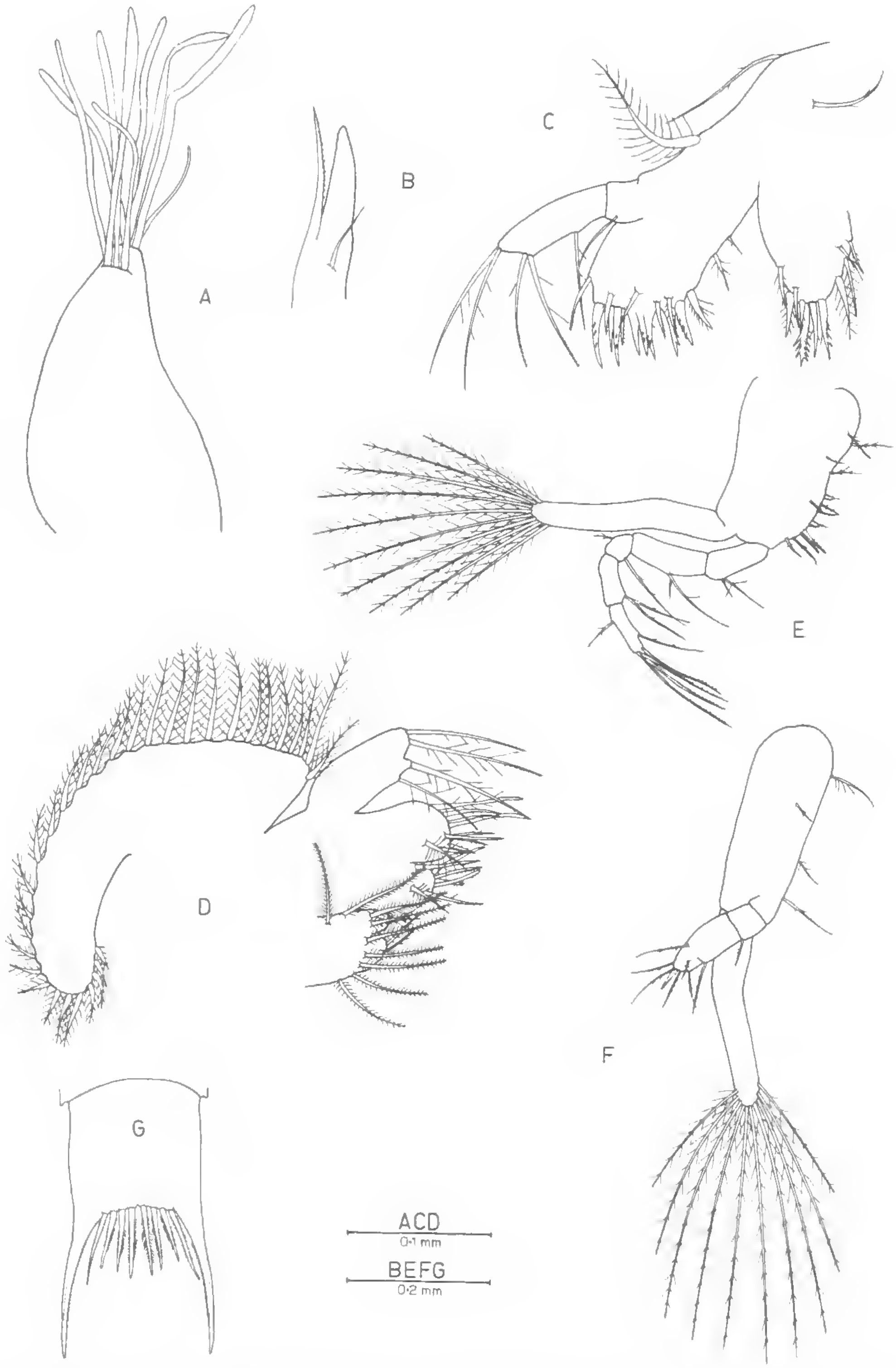

FIG. 5: *Macrophthalmus setosus* fifth zoea appendages. **A**. first antenna; **B**. second antenna; **C**. first maxilla; **D**. second maxilla; **E**. first maxilliped; **F**. second maxilliped; **G**. telson.